that they were able to enjoy the river at that time of year because of multiple use. Water, stored in a system built by farmers and ranchers, provided the late season recreation opportunity. Later, the outfitter stopped the trip so the public could share the thrill of finding gold with a recreational dredge miner.

Rather than focus on the mistakes (we've had ours, too), we should seek out grazers, miners and loggers who share our use of the resource and have exhibited responsible streamside and land-use practices. We should include them in a picture, presented to the public, that shows our public lands for what they are—vibrant, productive system for the enduring benefit of the American people.

Let's reduce the bickering and focus on the value of the whole: food for our families, clothing for our backs, wood for our houses, fuel and metal for our cars, power for light, fun for the weekend, wilderness for the soul. American's public lands can continue to be a positive element in our lives if we work responsibly to use, share and cherish them—together.—**Doug Tims**

Learning and Memory in Grazing Livestock Application to Diet Selection

Karen L. Launchbaugh and Fred D. Provenza

When you think of intelligent animals, a cow or sheep is probably not the first creature that comes to mind. With respect to grazing, however, livestock are smart. Researchers consistently report that livestock select diets more nutritious than if they foraged at random (Arnold and Dudzinski 1978). However, scientists disagree on how livestock know which foods are nutritious or toxic. Some traditional theories suggest that animals are born knowing what to eat and do not need specific learning experience. These theories suggest that diet selection is inflexible and stereotypic.

Range scientists have been reluctant to replace these traditional theories with concepts that depend upon animal learning and experience. However, many successful management practices which ranchers have been using for decades are based on the assumptions that livestock learn and remember the plants they eat. For example, many ranchers select replacement heifers from their own herd because they "know" the range better than heifers purchased from outside herds. Most managers realize that livestock deaths from poisonous plants generally increase when animals are not familiar with a particular plant, such as when livestock graze new pastures. A few savvy ranchers even wean animals on the same feed used for creep feeding because the calves seem to "recognize" the feed, eat more of it, and gain weight more quickly.

Many people may find it difficult to believe that livestock can remember the hundreds of plants necessary to survive on rangelands (Bailey and Rittenhouse 1989). Yet, recent research indicates that livestock can be trained to eat or avoid particular plants and they have substantial abilities to remember foods (Provenza and Balph 1988, 1990).

Although we don't know exactly how many plants a cow or sheep can remember, they probably can remember all the foods encountered while foraging on rangeland. Clark's nutcracker, a seed-caching bird, can remember the location of up to 9,000 food-storage sites (Balda 1980).

Livestock can also remember for years which foods are nutritious or toxic. Green et al. (1984) offered ewes and lambs wheat for one hour a day for as little as five days. Almost three years later, these lambs ate more wheat than lambs unfamiliar with wheat. The lambs apparently remembered wheat 34 months after first eating it. Food aversions are also remembered for many months. Lane et al. (1990) aversively conditioned heifers to avoid larkspur and they still avoided the plant a year later.

Diet Selection Through Learning

A diet selection system based on learning and memory would include the following elements: (1) mother as a social model, (2) cautious sampling of novel foods, and (3) the formation of food preferences and aversions based on gastrointestinal consequences.

Mother's Influence:

Livestock have a reliable model to follow at birth—their mother. A mother that avoids poisonous plants, teaches her offspring to avoid the plants (Provenza et al. 1991). Lambs quickly learn to avoid a "harmful" novel food their mothers were trained to avoid, and to consume a novel

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alternative selected by their mothers (Mirza and Provenza 1991). Young livestock can also learn appropriate food choices from other adult animals and peers (Thorhallsdottir et al. 1990).

Learning from mother may even begin before young herbivores start foraging. Flavors in the uterine fluid may influence food aversions (Smotherman 1982). Mother's milk also is a source of information for young livestock. Nolte and Provenza (1991) studied orphan lambs raised on onion-flavored milk and found that they later preferred onion flavored food. Thus, before lambs or calves ever take a bite of food, they may have substantial information about the forages in their environment.

Cautious Sampling:

Many researchers and ranchers have reported that livestock cautiously sample novel foods, a phenomenon called neophobia. Eating a small amount of novel forage may be a way for livestock to safely identify toxic plants.

Livestock respond differently to novel compared to familiar foods. When lambs become ill after eating a meal with several familiar grains and one novel grain (rye), they subsequently avoid rye but continue to eat the familiar grains (Burritt and Provenza 1991).

Sampling is also an important part of diet selection by experienced foragers. Range vegetation varies greatly in toxicity and nutritive value from plant to plant and season to season (Provenza and Balph 1990). Therefore, even experienced foragers must continually sample the foraging environment to keep track of changing food value (Westoby 1978).

Gastrointestinal Consequences:

Most mammals, including humans, have a highly developed neurological system for relating digestive consequences to the flavor of foods. If a cow or sheep eats a novel plant and subsequently becomes ill, it will develop a dislike for the plant (a conditioned food aversion). On the other hand, if a food is nutritionally satisfying, an animal develops a conditioned preference for the food (Provenza et al. 1991). In simplest terms, a cow or sheep simply selects foods it likes (positive postingestive effects) and avoids foods it doesn't like (negative postingestive effects) to acquire a nutritious diet.

Management Implications

Our assumptions about how livestock select forage guide grazing management decisions. We might implement different management practices based on whether or not we believe livestock need foraging experience to make dietary decisions.

Ranchers frequently move livestock to new foraging environments. Bulls, rams, or replacement females may be transported thousands of miles to a novel foraging environment as part of a breeding program. During winter or drought, animals may be transported to "greener pastures." Animal production often decreases after such moves (Zimmerman 1980).

If foraging preferences are stereotypic (innate), livestock moved to new environments should not require an adaptation period. However, if livestock must learn what forages to eat, intake and production will initially decrease when they are moved to novel foraging environments. The latter hypothesis is consistent with the fact that sheep, cattle, and goats unfamiliar with a particular type of rangeland spend more time grazing and ingest less forage than animals familiar with the range (Arnold 1970). This probably explains why many stockmen prefer to keep their own replacement females (Zimmerman 1980).

Animals also encounter novel foraging situations at weaning time, when many lambs and calves are placed in feedlots for fattening. Neophobia, displayed as reduced intake, may make it difficult for newly weaned animals to make the transition from range to feedlot. However, Ortega-Reyes et al. (1991) increased the intake of lambs during the first few weeks on feedlot by introducing lambs to whole barley two months before weaning. The increased barley intake in the feedlot reduced the time to slaughter by two weeks, which could significantly decrease feedlot operating costs.

If an animal's experience has little effect on diet preferences then vegetation use patterns can be affected only by changing the species of vegetation or species of animal. However, if livestock learn what foods to eat, they may be trained to eat or avoid particular plants to meet management objectives. The role of learning in forage selection is illustrated in a study by Burritt and Provenza (1990). They wanted to reduce the biomass of grasses and forbs to increase shrub growth of two palatable shrubs—serviceberry and mountain mahogany. To encourage this selective grazing they fed twelve lambs both shrubs and then administered a small dose of lithium chloride, which made them ill. The lambs subsequently removed the grass and forbs but avoided the shrubs as if they were poisonous.

It may also be possible to teach livestock to avoid poisonous plants, either by having inexperienced animals graze with their mother or other social models which avoid the plant, or by using aversive conditioning (Lane et al. 1990).

Conclusion

The intelligence of cows and sheep cannot be measured with an I.Q. test, but there is considerable evidence that livestock are quite knowledgeable about the plants they eat. Viewing livestock as mindless grazing machines with programmed foraging preferences may lead to invalid research designs and management decisions. In fact, it may be managerially dangerous to underestimate the learning abilities of range livestock.

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Alfalfa in Crested Wheatgrass Seedings

Robert R. Kindschy

Crested wheatgrass seedings have been criticized as being monotypic. Forbs such as legumes afford diversity and provide valuable summer forage to livestock and wildlife. White and Wight (1984), working in Montana, determined that crude protein concentration of alfalfas was almost twice that of grasses, and alfalfa produced nearly twice as much crude protein per unit of land. Several researchers have found that forage production is increased when a nitrogen fixing legume such as alfalfa is grown in association with seeded grass (Campbell 1963, Gomm 1964).

Addition of a perennial forb, such as alfalfa, to seedings of grasses increased both forage yield and plant diversity.

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Rumbaugh (1984) determined that crested wheatgrass produced 183 percent as much grass foliage when grown with legumes, as when it was grown without legumes. In addition, the alfalfa plants contributed directly in a major way to a higher total forage yield. Rumbaugh also observed that where native legumes had been eliminated by overgrazing, the range site was not receiving the benefit of the nitrogen that could be added by the legume-mediated fixation process. Reintroduction of the native species or replacing them with improved strains or other adapted legumes could help restore the site to full productivity.

Rosenstock and Stevens (1989) studied the effects of herbivores on alfalfa seeded in the pinyon-juniper community of central Utah. They determined that although alfalfa had decreased during the 24 years since establishment, alfalfa remained an important and persistent component of the forage resource.

During a September 1961 tour of the Malheur County area, I was advised by E.R. Jackman, that 'Nomad' alfalfa had persisted as an excellent forage in the Paradise Valley region north of Winnemucca, Nevada, in a winter cattle feed-lot! The southeastern Oregon climate was quite similar and such a legume appeared to offer considerable potential for forage enhancement. A major opportunity for alfalfa seeding occurred during the Vale rangeland rehabilitation project (1962–1973) in the Bureau of Land Management's Vale District in southeastern Oregon (Heady and Bartolome 1977). Some one hundred thousand acres of crested wheatgrass seedings were also seeded to 'Nomad' variety dryland alfalfa. Seeding techniques were discussed by me (Kindschy 1974) in an often quoted but unpublished Bureau of Land Management report concerning dryland alfalfa seeding.